(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 203 230**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 85303683.8

(22) Date of filing: 24.05.85

(51) Int. Cl.⁴: C 06 B 21/00, B 01 F 7/22

(43) Date of publication of application: 03.12.86
Bulletin 86/49

(84) Designated Contracting States: AT BE CH DE FR GB LI SE

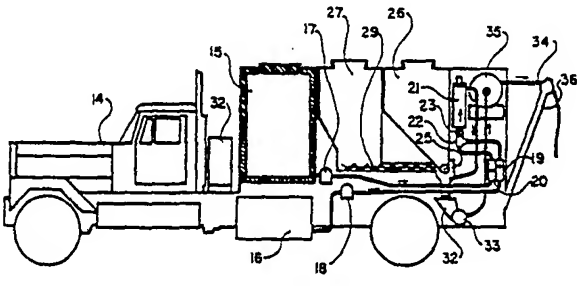
(71) Applicant: IRECO INCORPORATED, Eleventh Floor Crossroads Tower, Salt Lake City Utah 84144 (US)

(72) Inventor: Larsen, Raymond D., 1451 East 8685 South, Sandy Utah, 84092 (US)
Inventor: Lawrence, Larry D., 2563 South 3210 South, Salt Lake City Utah, 84109 (US)
Inventor: Sudweeks, Walter B., 734 South Woodmore Drive, Orem Utah, 84058 (US)

(74) Representative: Boon, Graham Anthony et al, Elkington and Fife High Holborn House 52/54 High Holborn, London, WC1V 6SH (GB)

(54) Apparatus and method for manufacture and delivery of blasting agents.

(57) A method and apparatus are provided for formulating and delivering emulsion slurry blasting agents in a self-contained, "on site," movable system, which houses the necessary apparatus for formulating the emulsion blasting agent. The movable system, for example a heavy duty truck (14) has an oxidizer salt solution container (15), a container (16) for a solution of liquid organic fuel and emulsifier, a blender (21) in which the emulsion phase is formed, and a conduit (34) through which the emulsion blasting agent is delivered to a borehole or other receptacle. Also disclosed is a blender which is particularly suitable for the purpose of the invention.



EP 0 203 230 A1

APPARATUS AND METHOD FOR MANUFACTURE AND DELIVERY OF BLASTING AGENTS.

The present invention relates to a method and apparatus for formulating blasting agents and delivering them in bulk into a borehole or other receptacle. More specifically, the invention relates to a method and apparatus for the "on-site" formulating and delivery of water-in-oil emulsion blasting agents. By "on-site" is meant that both the formulating and delivery operations are conducted at the blasting location or site. This means that the blasting agents are "site-mixed" in a movable apparatus as opposed to being "plant-mixed" at a remotely located, stationary facility. The advantages of this "site-mixed system" are described below.

Slurry explosives or blasting agents are used commonly in the mining industry. They generally contain a thickened oxidizer salt solution that forms a continuous aqueous phase throughout which is dispersed solid and/or liquid fuels, sensitizers, density reducing agents and other ingredients. Equipment for the bulk delivery of these blasting agents have been developed. For example, U.S. Patent Nos. 3,303,738 and 3,380,333 disclose a method and apparatus for the bulk delivery of slurry blasting agents into a borehole. The disclosed apparatus is a heavy duty truck upon which is housed equipment for storage and transportation of blasting agent ingredients, for the blending and mixing of such ingredients into a slurry blasting agent and for the pumping of the blended slurry blasting agent into a borehole. Since the truck is self-contained with respect to the equipment for formulating and pumping the slurry blasting agent, it can be driven to the desired blasting site and there operated so as to manufacture and deliver the slurry blasting agent on-site and into a borehole. Thus, the slurry blasting agent ingredients, which

are not detonatable by themselves, can be transported safely by the truck, and a detonatable blasting agent is formed only immediately prior to delivery of the agent into a borehole for subsequent detonation. The inherent safety advantages of this system are obvious.

Another advantage of this "site-mixed" "pump-truck" system is that the proportion of the ingredients being blended can be varied continuously or step-wise in a predetermined manner, and thus the composition of the slurry blasting agent can be tailored to meet varying blasting conditions, even within a single borehole. Other truck systems which simply repump or extrude slurry blasting agents previously formulated at a stationary facility do not have this advantage or the previously described safety advantage. The site-mixed system has received world-wide acceptance in many different types of mines and mining conditions. U.S. Patent No, 4,112,240 also discloses a site-mixed system.

In contradistinction to slurry blasting agents, emulsion explosives or blasting agents have a continuous oil phase rather than a continuous aqueous phase. Droplets of an aqueous solution of oxidizer salt are dispersed or emulsified throughout the continuous oil phase and, as desired, solid ingredients such as undissolved oxidizer salt, fuel, or density reducing agents also are dispersed throughout the continuous oil phase. These blasting agents are referred to herein as water-in-oil emulsion blasting agents.

Water-in-oil emulsion blasting agents are known in the art (see, for example, U.S. Patent Nos. 4,141,767; 4,110,134; 3,447,978 and 3,161,551). Water-in-oil emulsion blasting agents are found to have certain distinct advantages over conventional slurry blasting

agents, as explained in U.S. Patent No. 4,141,767. The above patents describe certain specialized methods for the manufacture of water-in-oil emulsion blasting agents, and a method and apparatus for the manufacture of such agents is described in U.S. Patent Nos. 4,008,108 and 4,138,281. However, the present applicants are unaware of any site-mixed system for the delivery of water-in-oil emulsion blasting agents.

The present invention can be described as a site-mixed system for water-in-oil emulsion blasting agents which can be either cap sensitive or non-cap sensitive. This invention combines the above-described advantages of a site-mixed system and of water-in-oil emulsion blasting agents. Despite the advantages of combining a site-mixed system with a water-in-oil emulsion blasting agent, such combination has not been achieved heretofore.

The invention provides an apparatus for the on-site bulk manufacture and delivery of a pumpable blasting agent, the apparatus comprising a movable base on which is housed a container for an oxidizer salt solution, means for delivering the blasting agent from the apparatus, and a conduit through which the blasting agent can be delivered into a borehole or other receptacle, characterised in that the base further houses a container for a solution of emulsifier and liquid organic fuel or individual containers for each ingredient, means for combining the oxidizer salt solution, emulsifier and liquid organic fuel to form a fluid mixture thereof, and a blender for blending the fluid mixture of oxidizer salt solution, emulsifier and liquid organic fuel to form a water-in-oil emulsion blasting agent.

The invention also provides a blender for blending a fluid mixture of ingredients of a water-in-oil

emulsion blasting agent into an emulsion phase, which blender comprises a housing having an inlet and an outlet, a shaft rotatably mounted within the housing, a plurality of blades affixed to and extending from the shaft and spaced apart along the axis of the shaft, a plurality of stators rigidly mounted within the housing and interposed in some or all of the spaces between the blades, and means for rotating the shaft and blades so as to blend the fluid mixture into the emulsion phase.

The invention further provides a method for the manufacture and bulk delivery of water-in-oil emulsion blasting agents comprising forming an oxidizer salt solution at a temperature above the salt crystallization temperature, combining the salt solution with a liquid organic fuel and an emulsifier to form a fluid mixture thereof, blending the fluid mixture to form a water-in-oil emulsion blasting agent wherein the step of blending includes shearing the fluid mixture with a combination of stators and rotatable blades, and delivering the emulsion blasting agent directly into a borehole or other receptacle.

In the accompanying drawings:

FIG. 1 is a flow diagram illustrating the method and apparatus of this invention;

FIG. 2 is a side elevation of a pump truck in partial schematic form;

FIG. 3 is a schematic rear view of the truck shown in FIG. 2;

FIG. 4 is a side elevation, partially broken away, of the blender;

FIG. 5 is a cross sectional view taken along plane A-A of FIG. 4; and

FIG. 6 is a side elevation, partially broken away,

of the blending and mixing means shown in FIGS. 2 and 3.

Fig. 1 is a flow diagram illustrating an embodiment of the invention. The apparatus comprises a container 1 for an oxidizer salt solution, a container 2 for a solution of liquid organic fuel and emulsifier, pumps 3 and 4, solution flow meters 5 and 6, a blender 7, a mixer 8, containers 9 and 10 (additional containers can be used) for dry, particulate ingredients, a delivery pump 11, a delivery conduit 12 and a power source 13. Not shown is a movable base upon which the apparatus preferably is housed. In operation, the solutions in containers 1 and 2 are pumped by pumps 3 and 4 through solution flow meters 5 and 6 into blender 7 in which the solutions are blended into an emulsion blasting agent. Optionally, dry, particulate ingredients from containers 9 and 10 are then mixed into the emulsion blasting agent to form the final water-in-oil emulsion blasting agent which is then pumped by delivery pump 11 through delivery conduit 12 into a borehole or other receptacle. Power source 13 provides power for all dynamic operations. The invention and certain preferred embodiments will be described in more detail below.

Fig. 2 is a side schematic view of a preferred embodiment of the invention. A movable base 14 houses the apparatus. Although shown in the drawing as a heavy duty truck, the movable base could be a skid, trailer, light duty truck, or other means. The movable base need not be capable of its own locomotion, as is the truck shown in the drawing, but a self-locomotive base is generally more mobile. The size and type of the base can depend upon the particular blasting application. For example, in underground applications, the base and housed apparatus may need to be relatively compact. In these applications, the

movable base could be a small trailer or skid or a light duty truck. For open pit blasting applications, the heavy duty truck shown in Fig. 2 is desirable because of its large volume capacity. Numerous types of movable bases could be employed by those skilled in the art.

An oxidizer salt solution container 15 is mounted on the movable base 14. The solution is aqueous and the dissolved oxidizer salt is that or a combination of those commonly employed in water-in-oil emulsion blasting agents (see, for example, U.S. Patent No. 4,141,767). A means (not shown) for maintaining the oxidizer salt solution at a temperature above its crystallization temperature is employed to keep the salts in solution. One means is simply to insulate the container, but a heating element could be used if necessary or desired.

Container 16 is for a solution of liquid organic fuel and emulsifier. Although these ingredients may be kept in separate containers, they are preferably combined into a single solution. The fuel and emulsifier are of the type commonly employed in the art. If desired, the solution container, or containers, may be heated for fluidity and compatibility with the oxidizer salt solution.

The solutions in containers 15 and 16 are pumped by pumps 17 and 18, respectively, from the containers through solution flow meters 19 and 20. The pumps can be types conventionally employed. Typical pumps include positive displacement pumps such as a Waukesha (0-150 gpm) for the oxidizer salt solution and a Delta (0-7 gpm) for the fuel and emulsifier solution. The solution flow meters can be standard tube and float rotameters or other flow monitoring means can be used. Solution flow can be adjusted

manually or automatically for predetermined flow rates.

The inorganic oxidizer salt solution and the liquid organic fuel and emulsifier solution (or separate streams of fuel and of an emulsifier solution) are combined prior to blending in a blender 21. As shown in Fig. 2, the solutions are combined to form a fluid mixture in a T-joint 22 prior to entering the blender through inlet 23. However, the solutions can be combined in other ways such as in blender 21 itself, in which instance the two solution flow lines (not numbered) from meters 19 and 20 would enter blender 21 through separate inlets, preferably located in either the bottom or lower sides of blender 21.

Blender 21 blends the inorganic oxidizer salt solution, liquid organic fuel and emulsifier with sufficient shear to form an emulsion phase of these ingredients, and thus an emulsion blasting agent. As shown in Figs. 4 and 5, a preferred embodiment of the blender comprises a housing 37, having an inlet 23 at the bottom thereof and an outlet 24 at the top thereof; a vertically extending shaft 38 rotatably mounted within the housing 37; horizontal blades 39 affixed to and extending laterally from the shaft 38 and spaced apart along the axis of the shaft 38; and stators 40 mounted within the housing 37 and interposed in some or all of the spaces between the blades 39. Preferably at least five sets of blades are affixed to the shaft, and at least two sets of stators are oppositely mounted within the housing. Fig. 5 shows one set of four blades at 90^{o} to one another. In Fig. 4, each stator is separated by three sets of blades. Preferably, the stators are rods which extend the majority of the distance between the housing and the shaft. The blades may be so angled as to counter but not impede the flow of the fluid mixture through the housing in order to increase a shearing action of the blades and stators on the

fluid mixture. Other types of blenders which could be used include homogenizers, colloid mills, shear pumps, ultrasonic mixers, and various other appropriate types of mixers.

To initiate production of the emulsion phase, it is preferred that a seed emulsion phase be formed first. This can be accomplished by closing outlet 24 and introducing a fuel-rich blend of the oxidizer salt solution, liquid organic fuel and emulsifier into the blender 21. Then, the blades 39 are rotated, for example at a speed of 1000 rpm, to blend the ingredients into an emulsion phase. The formation of the emulsion phase can be detected by a marked increase in viscosity of the blend. Once the blender becomes filled with the seed emulsion phase, the blender speed generally is increased to 1800 rpm, for example, the outlet is opened, the liquid fuel flow rate is reduced to the desired level, and the blending process then can proceed continuously or intermittently as desired.

As shown in Fig. 6, the emulsion phase goes through outlet 24 and into a dries mixer 25, wherein the dry ingredients (which are optional) are added from containers 24, 27 and 28 (Figs. 2 and 3) by screw conveyors 29, 30 and 31 and then mixed uniformly throughout the emulsion phase. The dry ingredients generally include one or more particulate fuels such as aluminium granules, prilled or ground oxidizer salt, and density reducing agents such as perlite or hollow plastic or glass spheres, which, if desired, could be pre-added to the oxidizer salt solution (see, for example, U.S. Patent No. 4,141,767). The mixing is preferably accomplished by means of rotating blades or paddles in the dries mixer 25. The blender 21 could be adapted to also function as the dries mixer, wherein the dry, particulate ingredients would be added to the blender

after formation of the emulsion phase. Thus, the blender and the mixer could be a single unit.

The completely formulated emulsion blasting agent leaves the dries mixer 25, enters pump funnel 32 and then enters delivery pump 33, which is preferably a positive displacement rotating screw pump, such as a Monoflo Mono (3-103 gpm H_2O at 0 kg/cm^2). The emulsion blasting agent then is pumped through conduit 34, preferably a heavy-duty rubber hose, and into a borehole or other receptacle. Preferably, the conduit 34 is reeled on reel 35 (shown in Fig. 2) so that the end of the conduit can be lowered and raised during the borehole filling process. The boom 36 can be used to position conduit 34 with respect to the borehole.

As an example of emulsion blasting agents formulated according to the above-described method and with the above-described apparatus, an emulsion of the type described in copending U.S. Serial No. 004,958 (which corresponds to U.K. Patent Application 2 042 495 A), containing 11 percent foil aluminium and 1.5% Microballoons (Registered Trade Mark) was formulated at a production rate of 136 kg/min. and pumped at 12 kg/cm^2 through a 30 m length of 5 cm diameter rubber hose. The emulsion blasting agent had a critical diameter of 38 mm at 5°C at a density of 1.26 g/cc.

The power source for all dynamic operations is preferably a hydraulic system powered by a diesel or gasoline engine. The details of such a system are not shown but are well-known by those skilled in the art. Other power means would include electrical, pneumatic and mechanical systems. All of these systems or combinations thereof could be used by those skilled in the art.

The pumps and screw conveyors can be adjusted either manually or automatically to provide the desired

flow rates of the various ingredients so that the formulated emulsion blasting agent has the desired composition. This composition can be changed during the formulating process, if desired, by manually or automatically adjusting the ingredient flow rates to the desired levels at the desired times. Thus, the composition of the blasting agent can be varied from the bottom of a borehole to the top, depending on the blasting agent characteristics desired, without interrupting the formulating and delivery process. Of course the blasting agent composition can also be changed from borehole to borehole if desired. An automatic metering system is not shown but is known to those skilled in the art.

CLAIMS:

1. An apparatus for the on-site bulk manufacture and delivery of a pumpable blasting agent, the apparatus comprising a movable base on which is housed a container for an oxidizer salt solution, means for delivering the blasting agent from the apparatus, and a conduit through which the blasting agent can be delivered into a borehole or other receptacle, characterised in that the base further houses a container for a solution of emulsifier and liquid organic fuel or individual containers for each ingredient, means for combining the oxidizer salt solution, emulsifier and liquid organic fuel to form a fluid mixture thereof, and a blender for blending the fluid mixture of oxidizer salt solution, emulsifier and liquid organic fuel to form a water-in-oil emulsion blasting agent.

2. An apparatus according to Claim 1 further comprising at least one container for a dry, particulate ingredient or ingredients; means for adding the dry, particulate ingredient or ingredients to the emulsion blasting agent; and a mixer for mixing the dry, particulate ingredient or ingredients throughout the emulsion blasting agent.

3. An apparatus according to Claim 1 or 2, wherein the blender comprises a housing within which are mounted stators and a rotatable shaft having blades that are affixed to and extend from the shaft.

4. An apparatus according to Claim 3 wherein the blender comprises a housing having an inlet and an outlet, a shaft rotatably mounted within the housing, a plurality

of blades affixed to and extending in a lateral direction from the shaft and spaced apart along the axis of the shaft, a plurality of stators rigidly mounted within the housing and interposed in some or all of the spaces between the blades, and means for rotating the shaft and blades so as to blend the fluid mixture.

5. An apparatus according to Claim 4, wherein the said inlet is at the bottom of the housing and the said outlet is at the top, wherein the shaft is mounted vertically within the housing and wherein the blades extend horizontally from the shaft.

6. An apparatus according to Claim 5, further comprising means for forcing the fluid mixture vertically through the housing and out the outlet.

7. An apparatus according to Claim 6, wherein the blades are angled so as to counter but not inhibit the flow of the fluid mixture through the housing in order to increase a shearing action of the blades and stators on the fluid mixture.

8. An apparatus according to any preceding Claim, wherein the movable base is a self-contained, motorized vehicle.

9. A blender for blending a fluid mixture of ingredients of a water-in-oil emulsion blasting agent into an emulsion phase, which blender comprises a housing having an inlet and an outlet, a shaft rotatably mounted within the housing, a plurality of blades affixed to and extending from the shaft and spaced apart along the axis of the shaft, a plurality of stators rigidly mounted

within the housing and interposed in some or all of the spaces between the blades, and means for rotating the shaft and blades so as to blend the fluid mixture into the emulsion phase.

10. A blender according to Claim 9, wherein the blades are in sets that are spaced apart along the axis of the shaft and the blades within each set extend radially from the shaft which thus functions as a hub for the blades.

11. A blender according to Claim 10, wherein at least five sets of blades are affixed to the shaft, at least two sets of stators are oppositely mounted within the housing.

12. A blender according to Claim 10 or 11, wherein each set of blades contains four blades extending radially at 90 degree angles from each other.

13. A blender according to any one of Claims 9 to 12, wherein the stators are rods which extend the majority of the distance between the housing and the shaft.

14. A blender according to any one of Claims 9 to 13, wherein the inlet is at the bottom of the housing and the outlet is at the top, the shaft is mounted vertically within the housing and the blades extend horizontally from the shaft.

15. A blender according to Claim 14, further comprising means for forcing the fluid mixture vertically through the housing and out the outlet.

16. A blender according to Claim 15, wherein the blades

are angled so as to counter but not impede the flow of the fluid mixture through the housing in order to increase a shearing action of the blades and stators on the fluid mixture.

17. A blender according to Claim 15 or 16, wherein the forcing means is a pump.

18. A method for the manufacture and bulk delivery of water-in-oil emulsion blasting agents comprising forming an oxidizer salt solution at a temperature above the salt crystallization temperature, combining the salt solution with a liquid organic fuel and an emulsifier to form a fluid mixture thereof, blending the fluid mixture to form a water-in-oil emulsion blasting agent wherein the step of blending includes shearing the fluid mixture with a combination of stators and rotatable blades, and delivering the emulsion blasting agent directly into a borehole or other receptacle.

19. A method according to Claim 18 further comprising the additional steps of adding dry, particulate ingredients, as desired, to the emulsion blasting agent, and mixing the dry ingredients uniformly throughout the emulsion blasting agent.

20. A method according to Claim 18 or 19, wherein the salt solution and emulsifier are combined initially with an excess of liquid organic fuel and blended to form a seed emulsion phase and thereafter the salt solution, liquid organic fuel and emulsifier are combined in the desired proportions for the final emulsion phase.

21. A method according to Claim 18 or 19, wherein the liquid organic fuel and emulsifier first are combined

into a solution which then is combined with the salt solution prior to the blending step.

22. A method according to any one of Claims 18 to 21, wherein the shearing of the fluid mixture includes the step of delivering the fluid mixture to a blender comprising a housing having an inlet and an outlet, a shaft rotatably mounted within the housing, a plurality of blades affixed to and extending in a lateral direction from the shaft and spaced apart along the axis of the shaft, a plurality of stators rigidly mounted within the housing and interposed in some or all of the spaces between the blades, and means for rotating the shaft and blades, thereby to shear the fluid mixture and form an emulsion phase.

23. A method according to any one of Claims 18 to 22, wherein all steps are accomplished on a self-contained, motorized vehicle.

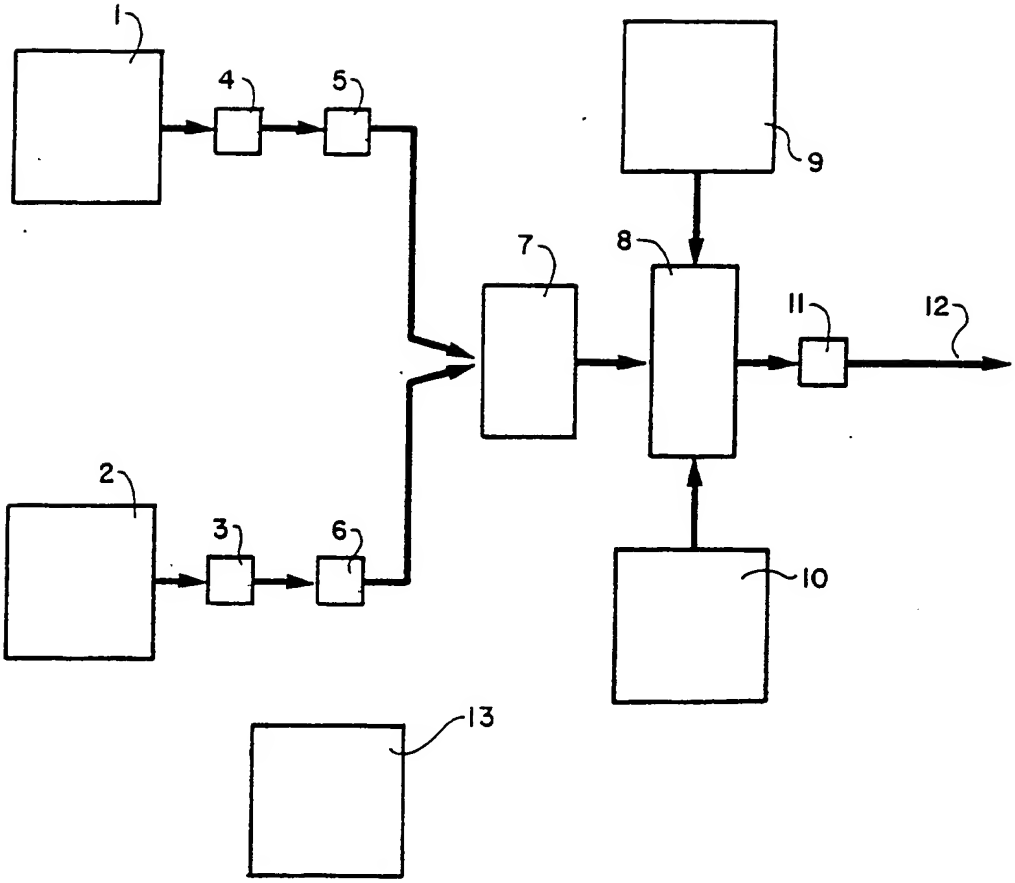


FIG. 1

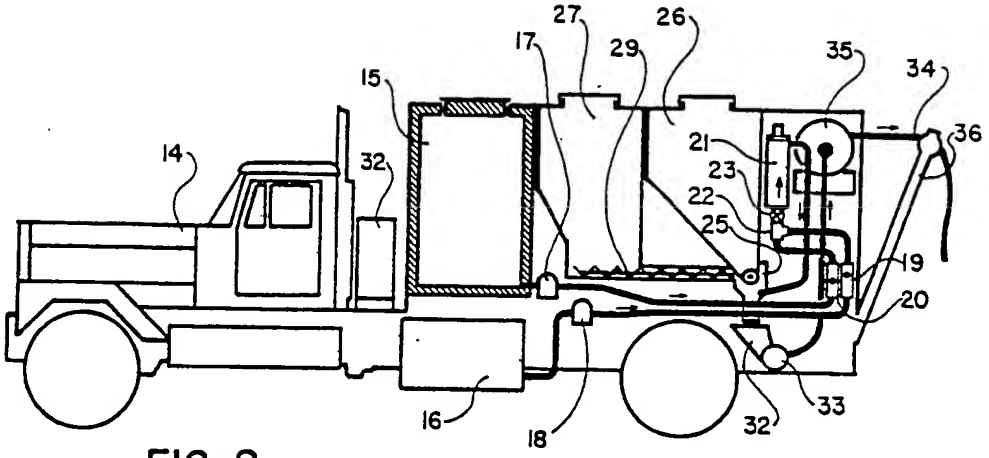

27
26
17
29
35
34
15
36
14
32
21
23
22
25
19
20
16
18
32
33

FIG. 2

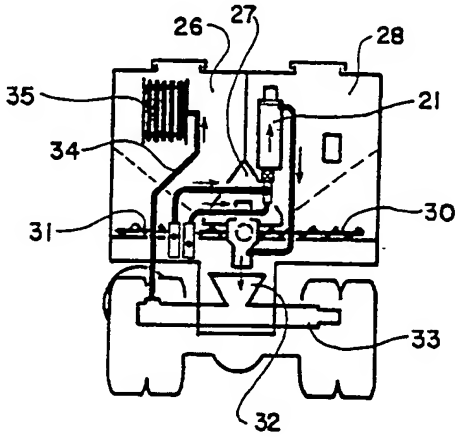

26
27
28
35
21
34
31
30
33
32

FIG. 3

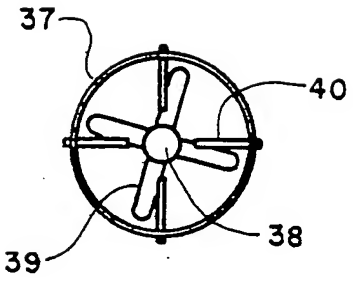


FIG. 5

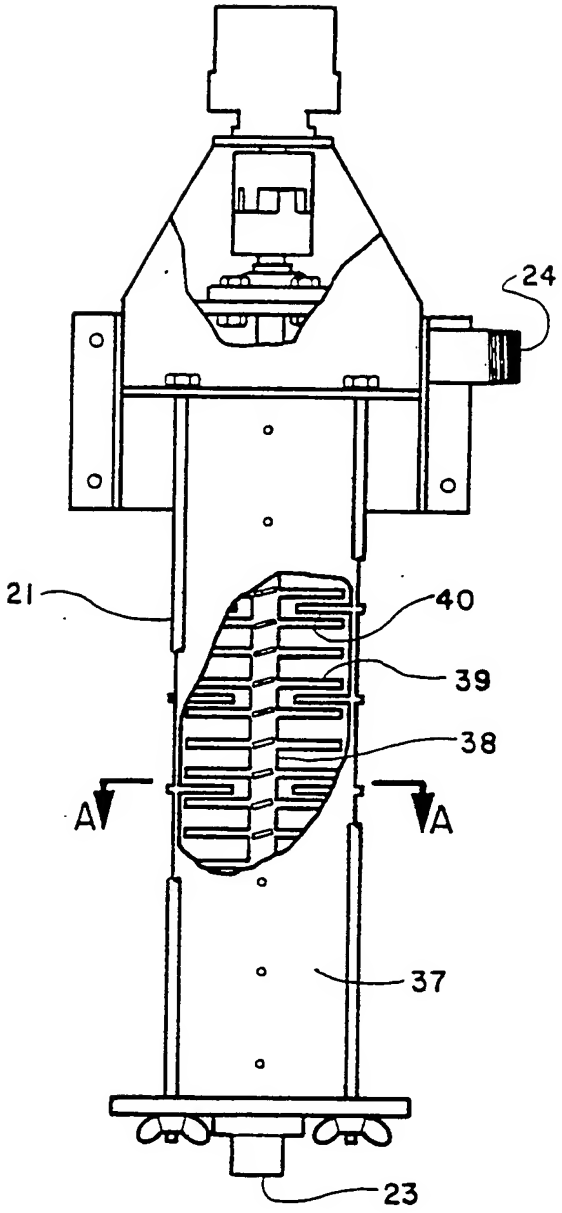


FIG. 4

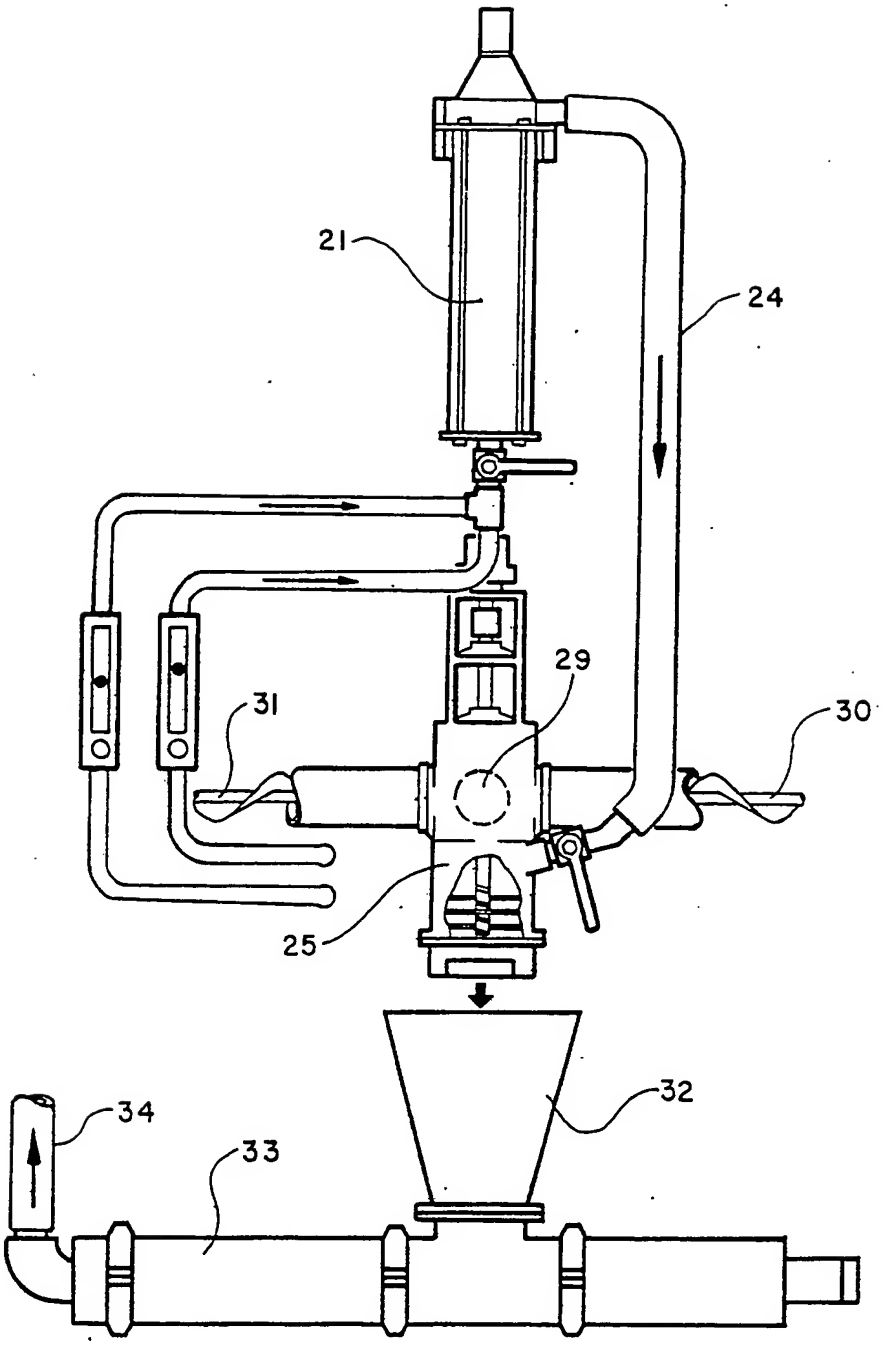


FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

0203230

Application number

EP 85 30 3683

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A-2 126 910 (AECI LTD.) * Claims 1-6; figure 1; page 2, lines 20-24 *	1,2,8, 18,19, 21,23	C 06 B 21/00 B 01 F 7/22
D,X	US-A-4 102 240 (M.A. COOK et al.) * Figures 1,2; column 1, lines 1-20 *	1-3,8	
A	GB-A-2 123 308 (C-I-L INC.) * Page 1, lines 42-123 *		
A	GB-A- 16 836 (WEILER-TER-MEER)(A.D. 1910) * Figures; claim 1 *	4-7,9-12,14-17	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	US-A-1 829 722 (L. KIRSCHBRAUN) * Claims 1,3; figure 8 *	3,4,6, 7,9,10 ,13,15 ,16,18 ,22	C 06 B 21/00 C 06 B 47/00 B 01 F 7/00 F 42 D 1/00
D,A	US-A-3 303 738 (R.B. CLAY et al.)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16-01-1986	KESTEN W.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503 03.82